

Staking Information

Section 12 of the Surveys Manual

Information Regarding State-Furnished Construction Staking

Typical Stakes: Types, Density, Placement and Markings

May '99



STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION
Engineering Service Center • Office of Engineering Technology
Geometronics Branch

Staking Information

Section 12 of the Surveys Manual

This document, Section 12, “Construction Surveys” of the *Surveys Manual*, provides information regarding typical construction staking performed by the California Department of Transportation (State)—the types of stakes furnished, their density, placement, and markings. It is a summary document and is not intended to cover all details regarding State-furnished construction staking, or all construction facilities and conditions.

Later versions of this document supersede earlier versions.

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12 Construction Surveys

Construction surveys establish basic line and grade for project construction. From these “control” stakes the contractor sets supplemental “working stakes.” The control stakes are used also by the Resident Engineer in checking the work for contract compliance.

This Section provides policy, procedures and general information regarding typical construction staking methods—the types of stakes furnished, and their density, placement, and markings.

12.1 Policy

Contract requirements regarding lines and grades, and construction stakes and marks, are included in the Caltrans *Standard Specifications*. Additional contractual requirements might be shown on the plans or included in the special provisions for the work.

The Department’s policy regarding State-furnished construction staking, as defined by this document and the Caltrans *Standard Specifications*, is to provide the necessary control stakes to establish the lines and grades required for the completion of the work.

Working stakes used by the Contractor in actually performing the work are the Contractor’s responsibility and are to be set by the Contractor’s forces from State-furnished control stakes.

Methods used to establish working stakes are at the Contractor’s option. These methods may include any means capable of maintaining the necessary accuracies as required by the *Standard Specifications* and by the Resident Engineer. Except for any contractual restrictions, the Contractor’s system for guiding the actual construction is the Contractor’s choice.

Generally, Contractors will not be required to use surveyor's theodolites, transits, precision levels, or electronic distance measurers; but State-furnished construction staking procedures might require the Contractor's use of improved-technology methods and equipment such as lasers.

The density of stakes, as defined by this document, will not be increased. When conditions permit, fewer construction stakes will be set. Examples are: (a) only slope stakes or final grade stakes might be set to complete a roadway involving minor grading; (b) final grade stakes might be used for curb control as well as for final grade; (c) curb stakes or curbs might be used for final grade stakes; and (d) existing pavement might be used to control contiguous widening work, instead of final grade stakes.

When private consultants under contract to Caltrans are providing construction staking, they should be provided a copy of this Section of the *Surveys Manual* along with the contract. Private consultants are responsible for providing all services and meeting all standards that are required by this Manual.

Nothing contained in this Manual or the consultant contracts with Caltrans is to be construed to limit consultants or Caltrans surveyors from their basic responsibilities for land surveying work as contained in the Land Surveyor's Act.

12.1-1 Responsibilities

Surveys

Construction staking is performed by the Surveys Branch in cooperation with Construction staff. To be fully successful, the Party Chief and Resident Engineer must act in concert. Each must cooperate to ensure a good working relationship. The Surveys Branch:

- a. Ensures statewide uniformity in construction staking
- b. Performs pre-contract-award State-furnished construction staking, as determined necessary by the Resident Engineer.
- c. Performs all State-furnished construction staking that requires the use of a survey party.
- d. Determines the methods and procedures to accomplish the State-furnished construction staking.
- e. Checks data furnished by the Design Engineer for completeness and discrepancies.

- f. Checks the conformity of planned lines and grades with existing conditions at pavement “conforms,” inlets and outlets of drainage facilities, etc.; advises the Resident Engineer of any problems; makes minor adjustments to lines and grades under the direction of the Resident Engineer.
- g. Advises the Resident Engineer of all discovered design issues (problems) regarding lines and grades, and records in daily Survey Party Reports.
- h. Keeps the Resident Engineer informed of pertinent construction staking issues; accepts construction staking requests *only* from the Resident Engineer; and keeps adequate records of State-furnished construction staking efforts (work accomplished, dates, time and resources required, survey data and restaking).
- i. Sets lath when normal staking is hidden by vegetation.

Note: These responsibilities apply equally to consultants, when performing construction staking under the direction of Caltrans personnel.

Resident Engineer

The Resident Engineer is responsible for the satisfactory administration and completion of the project, including the coordination of construction surveys in cooperation with the Surveys Branch. The Resident Engineer:

- a. At the preconstruction meeting or other times, explains to the Contractor with the assistance of Surveys personnel (i) the State-furnished construction staking procedures as detailed in this Section; (ii) the procedures and contract requirements for requesting State-furnished construction staking; and (iii) the contract requirements regarding preservation of State-furnished stakes.
- b. Coordinates all State-furnished construction staking requests.
- c. Verifies the Contractor’s requests for State-furnished construction staking are acceptable, including (i) the requested staking areas are ready for stakes; (ii) the stakes will be used in a reasonable time period; (iii) the stakes have been requested in a reasonable length of time in advance, and (iv) requests for “original” staking are truly original.
- d. Performs minor State-furnished construction staking that does not warrant the use of a survey party. Generally, the Structures Representative provides all State-furnished stakes and references for constructing the superstructure of structures.
- e. Determines when restaking costs are to be assessed to the Contractor and notifies the Surveys Branch so time sheets can be filled out properly.

- f. Resolves design issues (problems) regarding lines and grades; and checks/approves line and grade adjustments made by Surveys Branch personnel, under the direction of the Resident Engineer.
- g. Settles disputes regarding staking priorities and schedules.

Contractor

The Contractor:

- a. Submits suitable requests for State-furnished construction staking, ensuring that the requested staking areas are ready for stakes and that the stakes will be used in a reasonable time.
- b. Requests State-furnished construction staking a *reasonable length* of time in advance of starting operations in accordance with the contract requirements.
- c. When appropriate, establishes priorities for requested State-furnished construction staking; notes such priorities on the staking request.
- d. Submits all State-furnished construction staking requests to the Resident Engineer; not to Surveys personnel.
- e. Preserves State-furnished construction stakes in accordance with the contract requirements.
- f. Sets working stakes as required to complete the work.

Design Engineer

Provides the following information to Surveys at least 30-60 days prior to project award:

- a. Preliminary contract plans, with final reduced-size contract plans delivered by advertisement date, 1:200 staking plans, and annotated roadway cross-sections.
- b. Control diagram and coordinate list for the control used to design the project.
- c. All roadway alignments including main lines, ramps, branch connections, frontage roads, and detours.
- d. Roadway slope stake and grid grade listings (one or two per page), for all roadway and detour alignments.
- e. Drainage cross-sections, alignments with station/offset and coordinates for angle points, end points and curve data, and structure locations with station/offset and coordinates, if available, to the centerline point at the flowline.

- f. All profiles including roadway, curb and gutter, ditch, and channel.
- g. All lay-out-lines including ditches, channels, retaining walls, sound walls and benches, with station/offset and coordinates, if available, for angle points, end points and curve data.
- h. Taper, transition curve, and flare locations, including sufficient data to precisely define beginning and ending locations and elevations, radius points, offsets, and parabolic curve base line distances.
- i. Right-of-way data including station/offset and coordinates, if available, for angle points, end points, and curve data (from R/W).
- j. Data for structures including abutment and wing wall lay-out-lines, abutment fills, and pier alignments.

Note: All design data shall be delivered to Surveys Branch in both digital and hardcopy format.

12.1-2 Requests for Construction Staking

The Caltrans *Standard Specifications* require the Contractor to provide a written request for State-furnished construction staking. To facilitate the Contractor's written request and to ensure that all necessary information is included in the request, the Resident Engineer will furnish the Contractor a supply of Form H-ESP-16, "Request for Construction Staking," for this use. See Figure 12-1. Requests for staking shall only be accepted by Surveys after approval by the Resident Engineer.

When the Contractor requires construction staking, he shall notify the Resident Engineer of his requirements, in writing, on the form H-ESP-16, a reasonable length of time in advance of starting operations that require such staking. In no event shall a notice of less than two working days be considered a reasonable length of time. Two day notice is the minimum. Most staking requests will require longer notice to fulfill the requirement for "reasonability." For example, if a requested staking effort requires eight days to complete, a reasonable notice would be ten working days.

If the area or facility is not prepared satisfactorily for the staking, as determined by the Resident Engineer, the request for such staking will be voided by the Resident Engineer and the Contractor shall submit a new request for the staking when the area or facility has been properly prepared.

[illegible]

Figure 12-1

After receiving form H-ESP-16 from the Resident Engineer, the Surveys Branch schedules the work. To facilitate scheduling, requests should include calendar dates to indicate when stakes are needed and all requests should be specific as to area and types of stakes to be set. If no priority number is listed on a staking request, staking will proceed in the order listed or received. If a request includes more staking than the advance notice permits, it should be returned to the Resident Engineer, for staking priorities.

When staking is completed, the Party Chief makes his entries on the Staking Request form and returns the form to the Resident Engineer. Note when a request for original staking is actually for restaking.

12.1-3 Restaking

Section 5-1.07 of the 1994 Caltrans *Standard Specifications* states that:

“Stakes and marks set by the Engineer shall be carefully preserved by the Contractor. In case such stakes and marks are destroyed or damaged they will be replaced at the Engineer’s earliest convenience. The Contractor will be charged for the cost of necessary replacement or restoration of stakes and marks which in the judgment of the Engineer were carelessly or willfully destroyed or damaged by the Contractor’s operations. This charge will be deducted from any moneys due or to become due the Contractor.”

Surveys personnel must keep an accurate record of time required to complete restaking and report to the Resident Engineer any restaking that is done by using the Staking Request form H-ESP-16. The Resident Engineer is responsible for determining if charges for restaking will be made and for establishing restaking priorities.

12.1-4 Alternatives to Normal Staking

As determined by the Resident Engineer in cooperation with Surveys Branch personnel, additional State-furnished construction stakes will be provided for areas of staged construction, as necessary, to provide control for the lines and grades (see Section 12.5-6, “Final Grade Stakes, Staged Construction”).

State-furnished construction stakes will be provided for facilities not covered by this document to control lines and grades, as determined necessary by the Resident Engineer in cooperation with the Surveys Branch personnel.

In cooperation with the Resident Engineer and the Contractor, alternate State-furnished construction staking procedures (stake density, placement, and markings) will be considered to facilitate the Contractor’s construction methods, providing such alternate procedures do not require more Caltrans surveying resources than the methods outlined in this document.

For reconstruction and rehabilitation work, other State-furnished construction staking procedures might be used when the staking procedures described by this document are impractical, as determined by the Surveys personnel. For example, reference marks with a stationing identification might be painted on existing pavement and listings provided to the Contractor of elevations, distances, or cuts/fills as appropriate.

12.2 Planning Research and Office Preparation

12.2-1 Research

Construction surveys generally require minimal research efforts. Research of Surveys Branch files may be required for the retrieval of vertical and horizontal project data that will be used in the planning and setting of supplemental construction control. For additional information refer to Section 9, "Project Control."

If land net monumentation will be disturbed by construction, research and planning for land net field ties, monumentation renewal, corner restoration, and perpetuation of monuments and lines must be undertaken as required by Section 10, "Right-of-Way Surveys," of this Manual and Section 8771 of the Business and Professions Code.

12.2-2 Office Preparation

Surveys office staff is responsible for checking to ensure that the data obtained from the Design Branch (see Section 12.1-1, "Responsibilities – Design Engineer") is both complete and suitable. Missing data, design errors and uncertainties must be reported to the Design Engineer or the Resident Engineer as appropriate. Surveys personnel should not revise design data without the approval of the Design Engineer and/or the Resident Engineer.

The Surveys Branch should develop a strong partnership with Design to ensure that the information outlined in Section 12-1.1, "Responsibilities – Design Engineer," is provided in a ready-to-use format. Duplication of efforts by Design and Surveys must be avoided.

Office staff, in consultation with the Party Chief, or the Party Chief prepares the information for staking commonly called the staking package. This staking package should include all information required to efficiently stake the project. If digital files are not available from the Design Engineer, Surveys Branch office staff should create them for use in the Caltrans Total Station Surveying System. Generally, field parties should not begin construction staking without a complete field package developed in an office environment where efficient, appropriate data processing capability is available.

12.2-3 Preconstruction Conferences

Resident Engineer/Surveys: The District Survey Engineer or designated representative should have a preconstruction meeting with the Resident Engineer. Any Party Chief(s) permanently assigned to a project should also attend this meeting. This meeting should occur soon after the Resident Engineer is assigned and precede any meetings between the Resident Engineer and the Contractor. The purposes of this meeting are to establish a working relationship between the Resident Engineer and Surveys personnel and to review the anticipated survey work, including tentative staking schedules. Anticipated survey requests prior to contract award should also be discussed.

Resident Engineer/Contractor: A Surveys representative should attend the preconstruction meeting between the Resident Engineer and the Contractor. Surveys personnel should provide the Contractor with a copy of this Section of the *Surveys Manual* and explain that, along with the Caltrans *Standard Specifications*, it represents Caltrans procedures concerning State-furnished construction staking. Surveys personnel should be ready to describe the types, placement and marking of stakes, and explain the survey request process. The need for preserving stakes and the restaking process should also be discussed.

12.3 Survey Standards and Procedures

12.3-1 Accuracy Standards

Refer to Section 5, “Accuracy Classifications and Standards.”

12.3-2 Procedures

The procedure for setting construction stakes using the Total Station Survey System is radial stakeout by coordinate pairs (or by station offset). Procedures for these methods can be found in the Caltrans Data Collection (CTDC) User’s Manual and Section 7, “Total Station Survey System (TSSS) Specifications,” of this manual.

12.3-3 Tolerances

Tolerance stated for each type of stake in this Section indicates the acceptable deviation of the position of each stake from its computed position *relative to the given set-up point*. When the stake is positioned within its tolerance it is deemed “good.” Staked positions are generally checked using the CTDC Stakeout Reports and if within tolerance, the staked position is accepted.

Tolerance values should not be confused with accuracy standards. Accuracy is a function of the random errors associated with the survey methods and procedures that are used for the whole survey project, including project control, construction control and construction survey set-up points. For construction surveys, survey accuracy standards indicate the expected variation in position based on random errors *for the set-up points*, not variation in the construction stakes themselves.

12.3-4 Checking

Sufficient independent field checks must be made at the discretion of the Party Chief to assure the integrity of the staking. The integrity of radial stakeout set-up points should be verified before use by taking check shots on other control points. All positions staked in the field should be checked against the computed positions and the results recorded in the form of CTDC Stakeout Reports or on stakeout listings, such as slope stake listings, provided by the Design Engineer.

12.3-5 Field Notes

Construction staking field notes in the form of CTDC Stakeout Reports, stakeout listings with actual staked positions noted, or other suitable forms, shall be filed with the Resident Engineer upon completion of staking.

12.4 Stake Markings

The stake marking format shown in this Section is used when marks are placed on Caltrans standard plastic marking cards which are attached to marker stakes. If the markings are placed directly on wood stakes, the surveyor may revise the marking format for grading stakes (slope stakes, final grade stakes, etc.) and curb stakes as follows:

- Station – back of stake
- Distance to Stationing Line – back of stake
- Elevation – back or side of stake

Distances and cuts/fills are measured from the reference point for the stake to the point (feature) being staked (referenced, located). The elevation markings are for the top of the reference point. Examples of reference points are (a) small hub in front of the marker/guard stake, (b) a hub and tack in front of the marker/guard stake, (c) a spike driven in front of the marker/guard stake, (d) a tack or nail in the marker/guard stake, (e) a nail in or paint spot on pavement, or (f) the stake itself, depending on the precision required and field conditions.

Distances are measured from the reference point in a direction away from the face (front) of the marker stake. The face is the side of the stake which shows the references (e.g., distance) to the point being staked (referenced).

Superelevations (pavement cross-slopes) are marked as percentages (vertical rise or fall, in meters, per 100 meter horizontal distance). The superelevation slope direction marking (plus or minus) *is determined FROM the STATIONING LINE "OUT"* (right or left), regardless of the location of the stake. The stationing line used to determine the slope direction is that line marked on the stake.

Slope ratios are marked as “vertical distance” to “horizontal distance” (e.g. 1:2) for all projects using metric units. Projects dimensioned in feet use ratios of horizontal distance to vertical distance (e.g. 2:1). The direction of the slope (plus or minus) is not shown (marked).

When an elevation is shown on the plans for a point to be staked, reference stake markings will show only the reference point elevation, not a cut or fill to the point being referenced. Exceptions are if the planned lines or grades are adjusted to conform to existing conditions, or for other reasons as directed by the Resident Engineer.

The Resident Engineer should be immediately advised of any discrepancies between the plans and the stake markings; e.g., a cut or fill marked on a stake does not agree with that determined from the plans and the stake elevation. (Note: Some discrepancies might occur because of required field adjustments.)

12.4-1 Stake Marking Format

The markings at the top of the stake provide information about the given stake (its identification, location, etc.). The “a”, “b”, etc. listed below, and in the sections that follow, refer to the example stake marking notations.

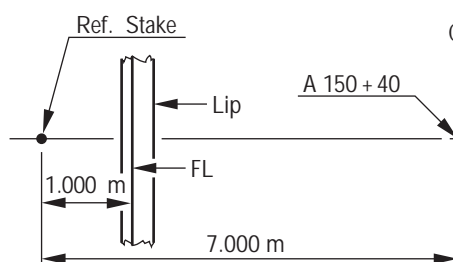


Figure 12-2

- Feature being staked (referenced, located); e.g., slope, final grade, sign foundation, abutment, etc.
- The line defined by the reference stakes (reference point, marker stake and line stake). If a full station is marked, such as “A 150 + 40”, the reference stakes are set on a line normal or radial to the stationing line at the specified station. If only the line is marked, such as “A line”, the reference stake is set on the line, not on an offset.

Note: Stations are 100 m.

- Distance normal or radial from the reference point to the stationing line identified in the marking above, along the specified cross-section. This marking is only provided *when a full station marking is given above*.
- Elevation of the reference point.

CS B-2	a.
A150+40	b.
7 000	c.
EL 1226 084	d.
C2 154	e.
1 000 FL	f.
	g.
F0 012 LIP	h.
	i.

Figure 12-2A

The next set of markings provide information about the point (feature) that is being staked (referenced, located).

- e. Cut or fill from the reference point to the point that is being staked. If elevations are shown on the plans, cuts or fills are not provided unless field adjustments are made.
- f. Distance from the reference point to the point and the line being staked. Note: Generally, this line intersects either perpendicularly or radially the line defined by the stake pair (see stake marking “b”).

Additional markings follow, below marking “f”, as required to provide the necessary control information for establishing other lines and grades.

Distances, elevations, and cuts/fills should be marked to the nearest millimeter for all references except for slope stakes, abutment fill stakes, and rough grade stakes, all of which should be marked to the nearest 10 mm.

12.4-2 Stake Color Code

Stakes are color coded to conform with the following table.

Type of Stake	Description	Color*
Horizontal Control	Coordinated control points, control lines, control reference points, centerline, alignments, etc.	White/Red
Vertical Control	Bench marks	White/Orange
Clearing		Yellow/Black
Grading	Slope, intermediate slope, abutment fill, rough grade, contour grading, final grade, etc.	Yellow
Structure	Bridges, sound and retaining walls, box culverts, etc.	White
Drainage, Sewer, Curb	Pipe culverts, junction boxes, drop inlets, headwalls, sewer lines, storm drains, slope protection, curbs, gutters, etc.	Blue
Right-of-Way	Fences, R/W lines, easements, property monuments, etc.	White/Yellow
Miscellaneous	Signs, railings, barriers, lighting, etc.	Orange

* Flagging and marking cards, if used.

12.4-3 Stake Marking Abbreviations

Commonly used stake marking abbreviations are listed below. (Note: This is not a complete list of all marking abbreviations).

20B	An example of a sign identification number.	D/L	Daylight; see above
34-a	An example of identification number of a drainage facility (system and unit number).	DI	Drainage inlet
ABUT	Abutment	DIT	Ditch
Ahd	Ahead	DS	Drainage stake
B-2	An example of a designation for a type of curb.	PT	End curve
PC	Begin curve	ECR	End of curb return
BCH	Bench	EL	Elevation
BCR	Begin curb return	ELEV	Elevation
BEG	Begin or beginning	END	End or ending
BSR	Begin slope rounding	EP	Edge pavement
BL	Base line	ES	Edge shoulder
BK	Back	ESR	End of slope rounding
BR	Bridge	ETW	Edge traveled way
BSW	Back of sidewalk	EW	End wall
C	Cut	F	Fill
CHNL	Channel	FDN	Foundation
CL	Centerline	FE	Fence
CP	Catch point	FG	Finish grade
CURB	Curb	FGS	Final grade stake
CS	Curb stake	FL	Flow line
DAY	Daylight; daylight the cut or fill or daylight point/line (point/line of no cut/fill)	FLC	Flow line curb
		GRT	Grate
		GTR	Gutter
		HP	Hinge point
		ISS	Intermediate slope stake
		INV	Invert

L	Length	R	Radius
L/2	The mid-point of a longitudinal facility. Most often used for drainage stakes for long facilities.	RCS	Rough grade stake
L/4	Same as L/2, except for a quarter-point.	RP	Reference point; the stake, mark, or point is a reference to another specific point.
LIP	Lip of a feature, such as the lip of a gutter.	RP	The point (stake, tack, spike, etc.) to which all references (markings such as cuts/fills, distances, and elevations) are made.
L/O	Line only; the reference point is good for line only, not distance; if an elevation is given, the reference point is also good for elevation.	RPSS	Reference point for a slope stake; the reference point (stake) is not the actual slope stake point, but instead a reference to the slope stake point (catch point, end of slope rounding).
LOL	Lay-out-line	RT	Right
LT	Left	R/W	Right of way
MSR	Mid-point of slope rounding.	SE	Superelevation
OG	Original ground	SG	Sub grade
O/S	Offset	SHLD	Shoulder
PC	Point of curve	SL	Stationing line
PG	Pavement grade	SR	Slope rounding
PG	Profile grade	SS	Slope stake
PPP	Pavement plane projected. This is the plane of the traveled way projected to a specified point.	STR	Structure
PT	Point of tangency	SW	Sidewalk
QSR	Quarter-point of slope rounding.	TBC	Top back of curb
$\frac{1}{4}$ SR	Quarter-point of slope rounding; $\frac{1}{4}$ the distance from the beginning.	TC	Top curb
$\frac{1}{2}$ SR	Mid-point of slope rounding.	TOE	Toe; e.g., toe of a fill
$\frac{3}{4}$ SR	Quarter-point of slope rounding; $\frac{3}{4}$ the distance from the beginning.	TOP	Top; e.g., top of a feature, such as berm.
		TW	Traveled way
		WALL	Wall
		WW	Wingwall

12.5 Typical State-Furnished Stakes

This Section outlines the typical types, density, and placement of State-furnished construction stakes.

Alternate locations (positions) for the State-furnished construction stakes will be used if required by the construction conditions, as determined by the Surveys personnel. See example shown for Drainage Stakes.

12.5-1 Clearing Stakes

Clearing Stakes are set to show the limits of clearing and grubbing. Generally, the plan limits are those specified by Section 16 of the *Standard Specifications*, "Clearing and Grubbing." Clearing Stakes are only set when the limits are not defined by the contract. Clearing stakes are set for: clearing-only contracts, contracts requiring clearing to be completed for new aerial photography before grading, and where necessary as determined by the Resident Engineer in cooperation with the Surveys Branch to protect and preserve desirable natural features.

Stake Set: Lath at clearing limit, no reference point, see Figure 12-3.

Color Code: Yellow/black.

Spacing: Space longitudinally as necessary to provide intervisibility, but not less than 40 m.

Markings: Mark "CLEAR LIMIT" on the lath facing the centerline.

Setting Tolerance: Stakes should be set within 0.3 m of planned clearing limit.

Consider using a greater accuracy in park lands, areas where the entire right-of-way is to be cleared like orchards or urban areas, and where there is possibility of damage to highway facilities or utilities.

Checking: Check staking visually and by reviewing the CTDC Stakeout Reports and/or survey notes.

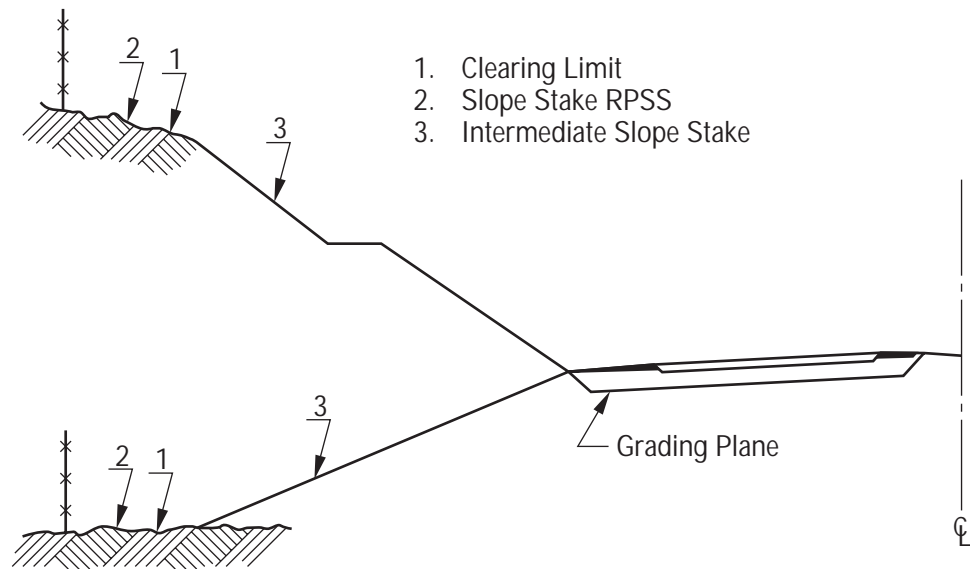


Figure 12-3

12.5-2 Slope Stakes

Slope stakes are set to control the construction of earthwork slopes. They are set to mark the designed intersection of a constructed slope and original ground or the “catch point.” Stakes are not set at the catch points, but elevations of design positions for catch points should be checked in the field. Instead reference points (RPSS) are generally set at a constant offset distance from the catch point, generally 3 to 6 m. In some cases, one set of stakes may be used for several purposes, such as slopes, final grades and curbs. See Section 12.1, “Policy.”

Stake Set: Reference point with marker stake and, if required, a line stake at a convenient distance, generally greater than 3 m, from the reference point. Line stakes are set in areas where visual lines, normal or radial to the station line, cannot be established as in the case when staking ramps, where the one side that is staked is not normal to the mainline. Refer to “Markings” for information regarding staking of slope rounding. See Figure 12-4.

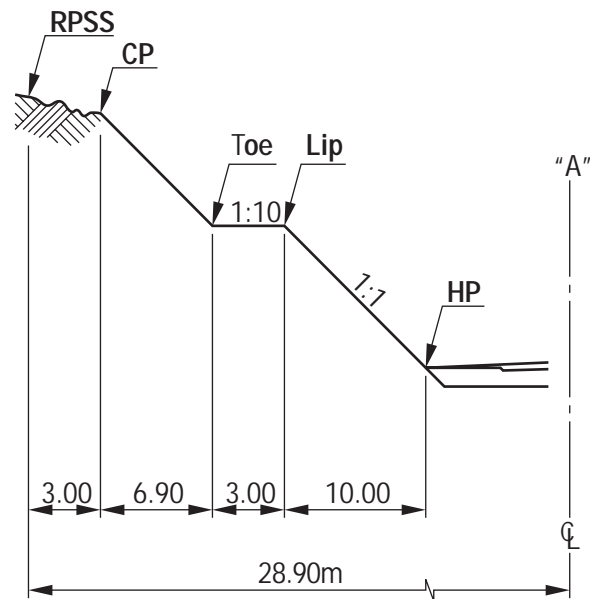


Figure 12-4

Generally, the actual ground location of the slope stake point is not determined in the field. Instead, locations determined from the plans and cross-section information are used. Thus, the slope stake point as staked *might not be actually on the ground surface*, it might be above or below the ground surface (see “Checking,” below). In these cases, it is the Contractor’s responsibility to determine the actual ground location of the slope stake point as necessary.

Color Code: Yellow.

Spacing: Space longitudinally every 40 m. Decrease spacing to 20 m when necessary for intervisibility of stakes, on curves of less than 300 m radius, or when cuts/fills are in excess of 3 m.

Markings: The following list refers to the example stake marking Figure 12-4A.

- a. “RPSS” identifies the stake as a reference point to the slope stake point (catch point or end of slope rounding); in Figure 12-4A, the catch point.
- b-d. These markings follow the general stake marking format (see Section 12.4-1, “Stake Marking Format”). In Figure 12-4A, the reference point for the “RPSS” is on the “A” 50+40 cross-section, 28.90 m from the “A” stationing line. It has an elevation of 1298.15 m.

- e-f. The plus or minus in elevation and the distance from the “RPSS” reference point to the actual slope stake point. Marking “f” also identifies the kind of slope stake point that is being referenced. In Figure 12-4A, the slope stake point is a catch point, and it is 0.64 m below and 3.00 m from the reference point.
- g-o. Each set of markings shows the cut or fill and distance from the slope point defined by the previous set of markings to the next slope point, and identifies the kind of grading point (line) that is being referenced. The cuts/fills and distances are NOT from the “RPSS” reference point, and ONLY the FIRST set of markings is from the slope stake point. This is sometimes called “point to point” or “then” slope staking.

Each set of markings consists of three markings—cut/fill, distance, and slope ratio. The distance marking also identifies the kind of grading point (line) that is being referenced.

RPSS	a.
A 50+40	b.
28 ⁹⁰	c.
EL 1298.15	d.
-0 ⁶⁴	e.
3 ⁰⁰ CP	f.
C 6 ⁹⁰	g.
6 ⁹⁰ BCH	h.
TOE	i.
1:1	j.
F 0 ³⁰	k.
3 ⁰⁰ BCH	l.
LIP	m.
1:10	n.
C 10 ⁰⁰	o.
10 ⁰⁰ HP	
1:1	

Figure 12-4A

For Figure 12-4A –

First Set of Markings: From the catch point, there is a cut of 6.9 m on a 1:1 slope (6.90 m horizontally) to the toe at the bench.

Second Set of Markings: From the bench toe (not from the catch point), there is a 0.3 m fill on a 1:10 slope (3.00 m horizontally) to the lip of the bench (the lip is 0.30 m above the bench toe).

Third Set of Markings: From the lip of the bench, there is a cut of 10.00 m on a 1:1 slope (10.00 m horizontally) to the hinge point.

Slope Rounding Stake Markings: If staked, slope rounding points are referenced in the same manner as other slope points, as outlined above; i.e., point to point. The need for slope rounding stake markings will be determined by the Surveys personnel in cooperation with the Resident Engineer. General slope rounding staking (stake marking) guidelines, based on the slope rounding length, are as follows:

- *Length 6 m or Less:* No slope rounding references provided. It is the responsibility of the Contractor to construct the slope rounding as shown on the plans.
- *Length Over 6 m to 12 m:* Beginning, mid-point, and ending (the slope stake point) are referenced.
- *Length Over 12 m to 30 m:* Beginning, quarter points, mid-point, and ending (the slope stake point) are referenced.
- *Length Greater than 30 m:* Slope rounding points are referenced at a 10 m interval.

Setting Tolerance: RPSS stakes should be set within 30 mm both horizontally and vertically.

Checking: Check staking visually and by reviewing the CTDC Stakeout Reports and/or survey notes. Catch points should be located and checked against the design positions. If the difference in elevation between the design position and the ground is over 0.3 m in light to moderate grading (cut or fill less than 3 m) or 0.6 m in moderate to heavy grading, the catch point should be located on the ground and a reference point set and marked reflecting the ground location of the catch point. All significant or consistent changes in catch point position should be reported to the Resident Engineer.

These are guidelines. The existing ground slope, proximity to the right-of-way line, and need to preserve existing property will effect these guidelines. It is the Party Chief's responsibility to determine when it is necessary to actually catch the slope consistent with efficient survey procedures.

12.5-3 Intermediate Slope Stakes

As determined by the Resident Engineer in cooperation with the Surveys Branch, only set when necessary with spacing of 20 m to control cut-slope benches, fill-slope struts, and slopes in very heavy grading (cuts or fills in excess of 10 m). For additional staking standards see Section 12.5-2, "Slope Stakes." See Figure 12-3.

12.5-4 Fence Stakes

Fence stakes are set to construct fences for highways with restricted access and for adjoining property owners when required by right of way (R/W) acquisition contracts. Caltrans R/W fencing for restricted access facilities is constructed within the R/W. Fencing for other

highways are constructed on the adjoiner's property. Fences are generally built 0.15 m from the property line. See Standard Plans numbered A85 and A86. See Figure 12-5.

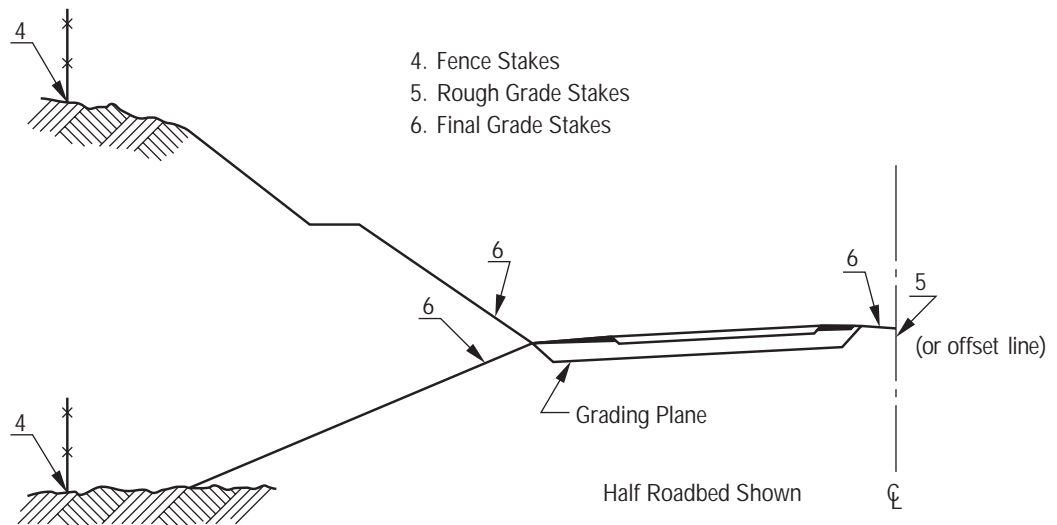


Figure 12-5

Stake Set: Reference point and marker stake, or marker stake only on the R/W line. R/W monuments may be set in place of temporary stakes at corners of Caltrans R/W. See Section 11, "Right of Way Surveys," for monument specifications and monumentation policy. Off-set lines should be set with regard to tapers required by the Standard Plans to provide 0.6 m separation between fencing and any existing or anticipated Caltrans R/W monuments (see Standard Plans A85 and A86).

Color Code: White/yellow

Spacing: Place at all fencing angle points and beginnings and ends of curves. Space stakes longitudinally every 60 m on tangents, 20 m on curves with a radius of 300 m or more, and 10 m on curves with radius of less than 300 m.

Marking: Stakes should be marked “Fence” or “Mon” if monument is set.

Setting Tolerance: Stakes for fencing set at Caltrans R/W corners should be set within 30 mm horizontally.

Checking: Check staking visually and by reviewing the CTDC Radial Stakeout Reports and/or survey notes.

12.5-5 **Rough Grade Stakes**

Rough grade stakes are set to aid rough finishing of the grading plane. They are only set when requested by the Resident Engineer when cuts or fills are greater than 10 m. Intermediate slope stakes will serve as rough grade stakes if within 10 m (cut/ fill) of the grading plane. See Figure 12-5.

Stakes Set: Reference point with a marker stake on only one line per roadbed, such as the centerline of construction.

Color Code: Yellow.

Spacing: Space longitudinally every 20 to 40 m, as determined by Surveys personnel with the concurrence of the Resident Engineer, depending on the construction conditions, alignment and grade.

Markings: Stakes should be marked “RGS” for rough grade stake and identify the line and station and off-set, if any, on which they are set, and give the cut/fill to finished grade for the point the stake references.

Setting Tolerance: Stakes should be set within 30 mm horizontally and vertically of calculated position.

Checking: Check staking visually and by reviewing the CTDC Radial Stakeout Reports and/or survey notes.

12.5-6 **Final Grade Stakes**

Final grade stakes are set when the rough finishing of the grading plane is completed. State-furnished final grade stakes are set only once for each grading plane. This one set of

final grade stakes controls all elements of the structural section (the grading plane, subbase, base, and pavement). See Figure 12-6. In some cases, one set of stakes may be used for several purposes, such as slopes, final grades and curbs. See Section 12.1, "Policy."

Staged Construction: The Resident Engineer, in cooperation with the Surveys Branch personnel determines staking needs for staged construction. A common form of staged construction is widening of existing pavement. Generally, the longitudinal spacing for this type of staged construction is the same as conventional construction, but the types of stakes and markings used will depend on conditions found on specific projects. See Figure 12-7.

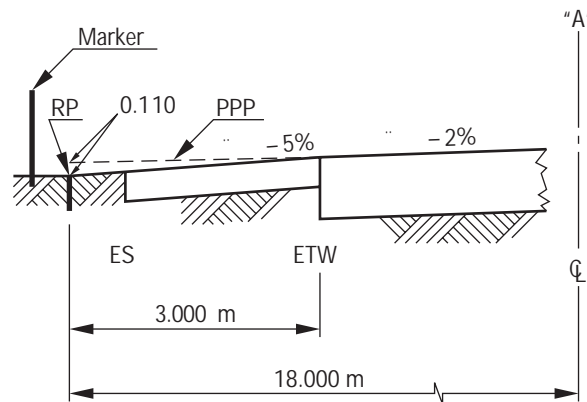


Figure 12-6

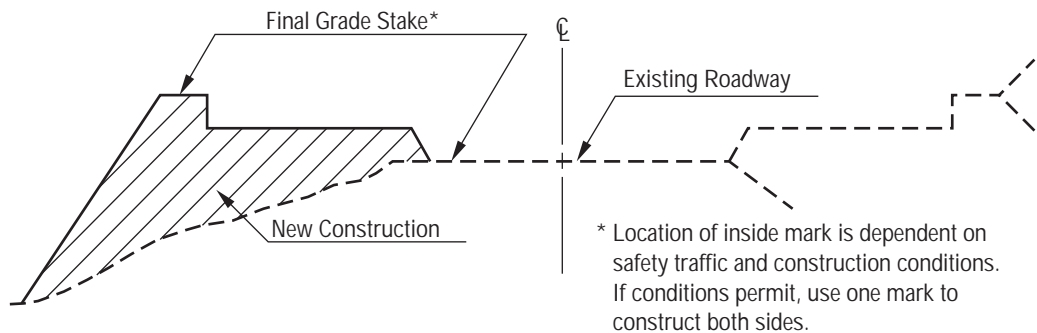


Figure 12-7

Stake Set: Reference point and marker stake, at a constant horizontal offset to the edge of the traveled way. Offset should be determined in cooperation with the Resident Engineer and the Contractor.

Color Code: Yellow.

Spacing: Space longitudinally every 20 m along tangents and curves except for curves with a radius of under 300 m, in which case spacing should be 10 m.

Markings: Stakes should be marked as shown on the following two examples. Notations a through d are as outlined in Figure 12-7A and 12-7B.

- a. “FGS” identifies the stake as a final grade stake.
- b-d. The reference point for the stake is on the A 42+40 cross-section, 18.000 m from the “A” stationing line. It has an elevation of 1022.450.
- h-i. The superelevations of the pavement surfaces *from the stationing line “out”* (left/right). For the example, the traveled way superelevation is –2.0% and the shoulder superelevation is –5.0%. Note: An even superelevation (e.g., 2.0%) also will be marked as 2%.

Two options are used to mark cuts/fills for the final grade stakes. The option used will be determined by the Surveys personnel and the Resident Engineer.

Option A:

- e-f. The cut or fill to the plane of the traveled way pavement surface projected to the reference point (PPP); see Figure 12-6. In Figure 12-7A, the PPP is 0.110 m above the reference point at the reference point.

Note: The line designated in the “f” marking (the “PPP” line) coincides with the line designated in marking “b”, the cross-section line. This is an exception to the general marking concept that lines designated in markings “b” and “f” intersect.

g. The horizontal distance to edge of traveled way.

Option B:

e-f. The cut or fill and distance from the reference point to the edge of the traveled way; in Figure 12-7B, the traveled way edge is 0.060 m above and 3.000 m from the reference point.

Setting Tolerance: Set stakes within 10 mm horizontally and 7 mm vertically of calculated position. (Vertical tolerance is only applicable if a specific elevation is being set.)

Checking: Check staking visually and by reviewing the CTDC Radial Stakeout Reports and/or survey notes.

12.5-7 Drainage Stakes

Stakes set for minor drainage structures, pipes, and similar facilities. See Figure 12-8

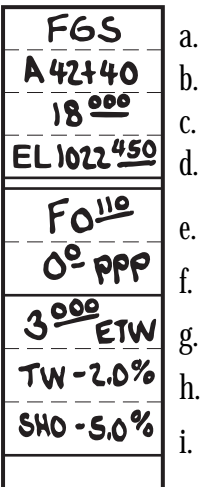


Figure 12-7A Option A

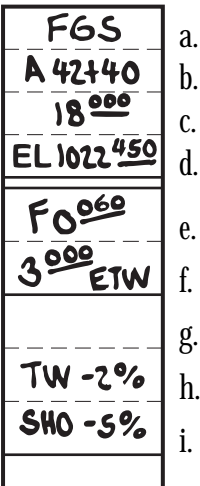
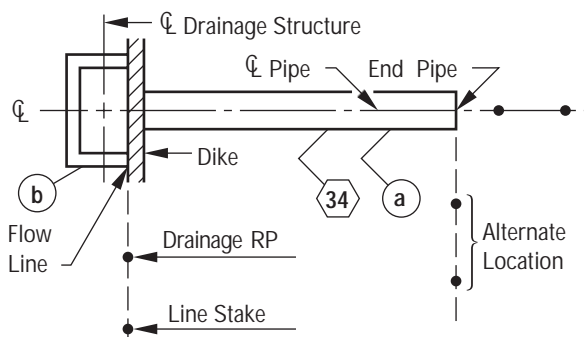


Figure 12-7B Option B

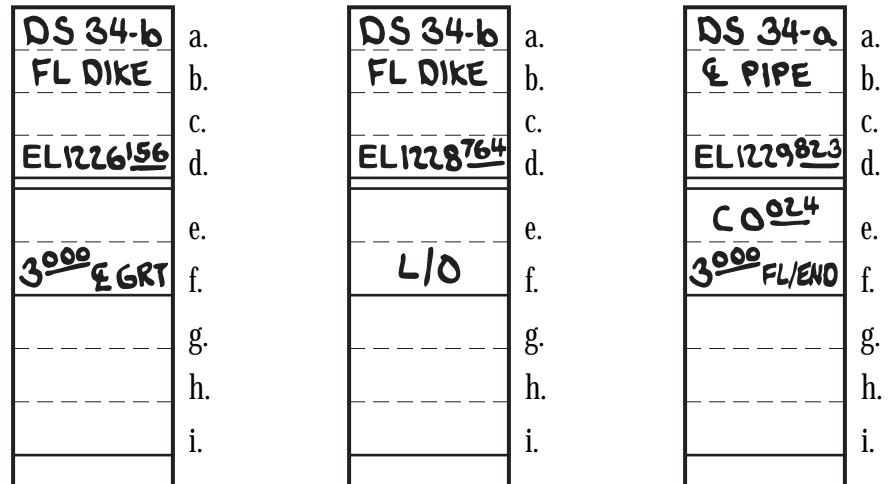
**Figure 12-8**

Stake Set: Reference point and marker and line stakes for the following points in drainage facilities:

- Ends of facilities
- Grade breaks
- Alignment breaks
- Junctions
- Inlets and similar facilities
- Risers and similar facilities (Note: The plumbing of risers and other similar facilities is the Contractor's responsibility; no reference stakes are set for plumbing.)
- Skewed cut-off lines, when necessary as determined by the Resident Engineer in cooperation with the Surveys Branch.

Color Code: Blue.

Spacing: In general, stakes are only set at the positions noted in the locations above, and no intermediate reference stakes are set along longitudinal drainage facilities such as pipes. When necessary, as determined by the Resident Engineer in cooperation with the Surveys personnel, intermediate reference stakes will be set (a) for staged construction, (b) to provide intervisibility between drainage stakes, and (c) for long, straight runs. When set for long, straight runs, the general spacing of intermediate stakes will be 60 m or more, as construction conditions permit (but not greater than 150 m).

**Figure 12-8A****Figure 12-8B****Figure 12-8C**

Markings: When the plans show control elevations (e.g., inlet and outlet invert elevations), reference stakes will show elevations, not cuts/fills. See Figure 12-8A, 12-8B and 12-8C.

- a. This marking identifies the stake as a drainage stake (“DS”) and the specific drainage facility being staked. If shown on the plans, drainage facilities will be identified by their drainage facility number (system number and unit number); for these examples 34-b and 34-a.
- b. The line defined by the reference stake and its companion line stake; in Figure 12-8A and 12-8B, the flow line of the dike and for Figure 12-8C, the centerline of the pipe.
- d. The reference point elevation; for these examples, 1226.156, 1228.764, and 1229.823.
- e-f. The cut or fill and distance from the reference point to the specific point being staked (referenced, located). If the plans show an elevation for the point being staked, a cut or fill is not provided, unless field adjustments are made. Marking “f” also identifies the line which that point is on.

Note: Generally, the line designated in marking “f” intersects (usually perpendicularly) the line defined by the stake pair (stake marking “b”). An exception is shown in Figure 12-8C, where the two lines coincide. In these cases, the stake will identify what point is being staked, if necessary (e.g., “FL/END”).

For these examples –

Figure 12-8A: The intersection point of the grate centerline and the dike flow line is 3.000 m from the reference point.

Figure 12-8B: This is a “line only” point which together with the Figure 12-8A stake defines the flow line along the dike at drainage facility 34-b.

Figure 12-8C: The flow line at the end of drainage facility 34-a is 0.024 m below and 3.0 m from the reference point.

Setting Tolerance: Set stakes within 10 mm horizontally and 7 mm vertically of calculated position. (Vertical tolerance is only applicable if a specified elevation is being set.)

Checking: Check staking visually and by reviewing the CTDC Stakeout Reports and/or survey notes.

12.5-8

Curb Stakes

In some cases, one set of stakes may be used for several purposes, such as slopes, final grades and curbs. See Section 12.1, “Policy.”

Stake Set: Reference point and marker stake at a constant horizontal offset distance from the flow line. See Figure 12-9.

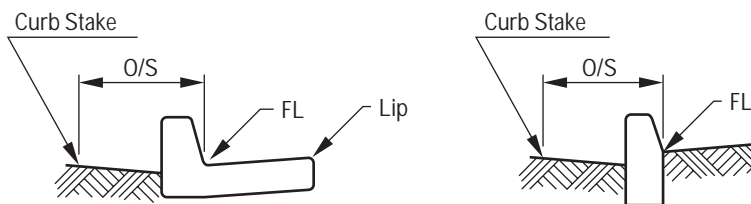


Figure 12-9

Color Code: Blue

Spacing: Space longitudinally every 20 m and at beginning and end of curb and beginning and end of horizontal and vertical curves. When grade is less than 0.3 percent or radius of curvature is less than 300 m space every 10 m. A lesser spacing may be used for flares when necessary, as determined by the Surveys personnel.

Markings: Reference stakes show the horizontal offset distance, cuts/fills to the flow line of the curb, and for non-standard curbs, cuts/fills (from the flow line) to the top-front-edge of the lip. See Figure 12-9A.

- | | |
|------------------------|----|
| CS B-2 | a. |
| A150+40 | b. |
| 8 ⁰⁰⁰ | c. |
| EL 1226 ⁰⁸⁴ | d. |
| C 0 ¹¹³ | e. |
| 1 ⁰⁰⁰ FL | f. |
| F 0 ⁰⁵⁰ LIP | g. |
| | h. |
| | i. |
- a. This marking identifies the stake as a curb stake ("CS") and the type of curb ("B-2").
 - b-d. These markings follow the general concepts. In Figure 12-9A, the reference point for the stake is on the A 150+40 cross-section, 8.000 m from the "A" stationing line. It has an elevation of 1226.084.
 - e-f. The cut or fill and distance from the reference point to the curb flow line. In Figure 12-9A, the *flow line* is 0.113 m below and 1.000 m from the reference point. (Note: All curbs are staked to the *flow line*. The flow line is the lowest point of the curb's top surface when in a standard orientation (non-superelevated) or, for curbs without a gutter, the intersection point of the adjacent pavement and the curb face.)
 - h. The cut/fill from the curb *flow line* to the curb lip (front-top). This marking is NOT provided for curbs shown in the Caltrans Standard Plans. A distance to the front-top-lip is NOT provided. In Figure 12-9A, the front-top-lip is 0.050 m above the flow line.

Figure 12-9A

Setting Tolerance: Stakes should be set within 10 mm horizontally and 7 mm vertically of the calculated position. (Vertical tolerance is only applicable if a specific elevation is being set.)

Checking: Check staking visually and by reviewing the CTDC Stakeout Reports and/or survey notes.

12.5-9 Minor Structure Stakes

Minor structure stakes are set for sign bases, lighting and signal foundations, other foundations, and similar miscellaneous structures.

Where minor structures are controlled by adjacent construction staking or adjacent facilities, no State-furnished stakes are provided. Where State-furnished construction staking is necessary, as determined by the Resident Engineer, reference stakes are set which establish the location, elevation, and alignment (orientation) for the minor structure. See Figure 12-10.

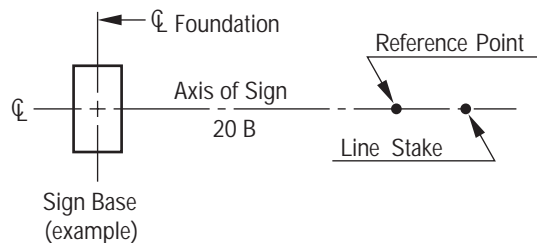


Figure 12-10

Stake Set: A reference point and marker stake and a line point with a guard stake at an offset that allows for excavation clearance.

Color Code: Orange

Spacing: N/A

Markings: See Figure 12-10A.

- a. This marking identifies the minor structure being staked; in Figure 12-10A, a sign. If shown on the plans, minor structures will be designated by their identification number. In Figure 12-10A, “20B” is the sign number shown on the plans.
- b. The line defined by the reference stake and its companion line stake; in Figure 12-10A, the centerline of the sign foundation.
- d. The reference point elevation; example, 320.621.
- e-f. The cut or fill and distance from the reference point to the specific point being staked. If the plans show an elevation for the point being staked, a cut or fill is not provided, unless field adjustments are made. Marking “f” also identifies the line which that point is on. In Figure 12-10A, the intersection point of the foundation centerlines (longitudinal and transverse) is 3.000 m from the reference point.

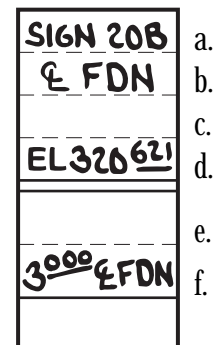


Figure 12-10A

Setting Tolerance: Stakes should be set within 10 mm horizontally.

Checking: Check staking visually and by reviewing the CTDC Radial Stakeout Reports and/or survey notes.

12.5-10 Abutment Fill Stakes

Abutment fill stakes are special slope stakes. The extent of State-furnished construction staking for abutment fills varies depending on the type and complexity of the abutment fill. Typical State-furnished construction staking is shown in Figure 12-11. Surveys personnel, in cooperation with the Resident Engineer and Structures Representative, will determine the actual staking provided.

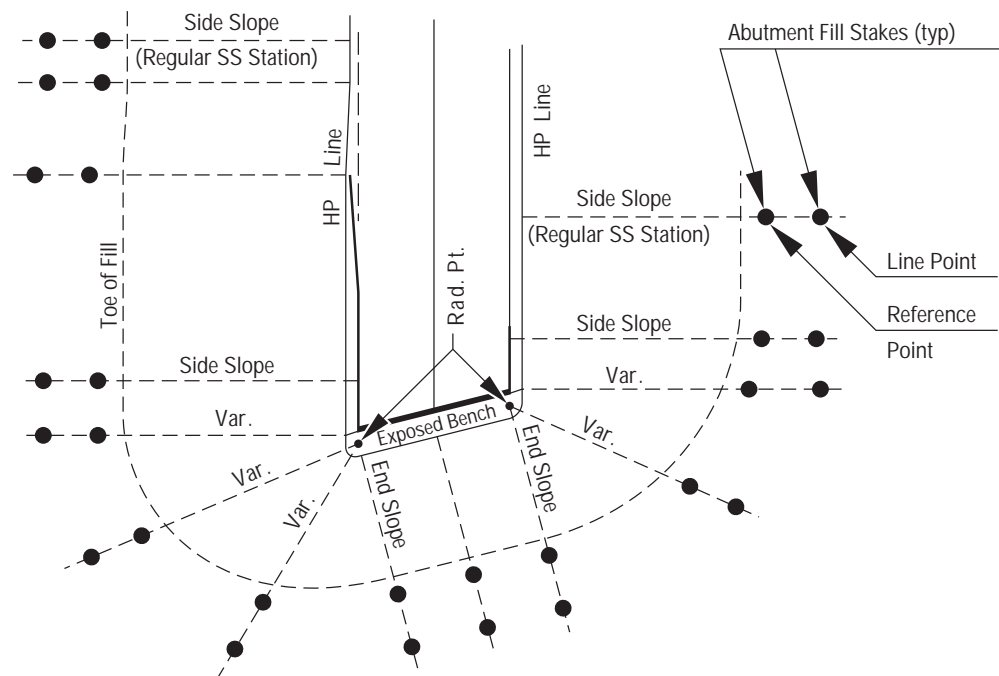


Figure 12-11

Stakes Set: A reference point, marker stake and line point for the following sections.

- Beginnings and ends of hinge point taper transitions.
- Last regular side slopes before the conic transitions.
- Opposite the exposed corners of abutments; normal or radial to the roadway centerline (only required for structures with exposed benches).
- Regular intervals along the conic transitions; maximum spacing of 20 m along toe.
- First regular end slopes after the conic transitions; normal to the abutment.
- Along the end slope; normal to the abutment.

Color Code: Yellow.

Spacing: Maximum spacing along end slopes and conic transitions is 20 m.

Markings: See Section 12.5-2, “Slope Stakes – Markings.”

Setting Tolerance: Stakes should be set within 30 mm horizontally and vertically of calculated position.

Checking: Check staking visually and by reviewing the CTDC Radial Stakeout Reports and/or survey notes.

12.5-11 Wall Stakes

Wall stakes are set to reference retaining and sound wall lay-out-lines (LOL). Only one line is to be referenced for each wall. See Figure 12-12.

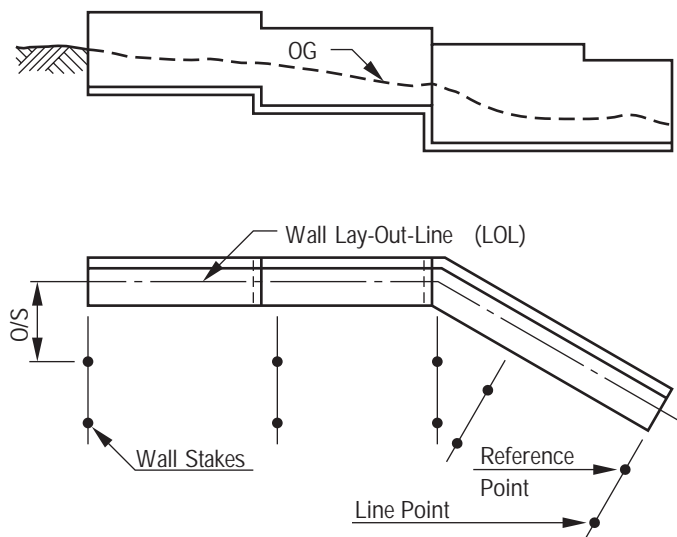


Figure 12-12

Stakes Set: A reference point, marker stake and line point with a guard stake.

Color Code: White.

Spacing: Stakes are set at the beginning and end of each wall, beginnings and ends of curves, LOL angle points, changes in footings (dimension, elevation), and change in wall height. Space of stakes longitudinally along LOL off-set line is determined by Surveys personnel, in consultation with the Resident Engineer and the structures representative, but shall not be longer than 20 m.

Markings: Reference stakes show the horizontal offset distance to the LOL and elevations, not cuts/fills. Refer to Section 12.5-9, “Minor Structure Stakes.”

Setting Tolerance: Stakes should be set within 7 mm horizontally and 7 mm vertically. (Vertical tolerance is only applicable if a specific elevation is being set.)

Checking: Check staking visually and by reviewing the CTDC Radial Stakeout Reports and/or survey notes.

12.5-12 Major Structure Stakes

The extent of State-furnished construction staking for major structures such as bridges varies, depending on the type and complexity of the structure and its construction. State-furnished staking of footings (bents, abutments, wingwalls, etc.) is normally provided by Surveys Branch personnel. Line and grade points on the superstructure are usually the responsibility of the Structures Representative, dependent on the type and complexity of the structure and its construction. Typical State-furnished construction staking is shown. Surveys personnel, in cooperation with the Resident Engineer and the Structures Representative, will determine the actual staking provided. See Figure 12-13.

No stakes are set by Surveys Branch personnel for the following:

- The locations of individual piles
- Individual pile cutoff elevations
- Falsework

Stakes Set for Footings (Bents, Abutments, Wingwalls): Two reference points, each with a marker stake that provide elevation, distance and line references for the controlling lines. A third reference stake, for “line only”, is set when required by the construction conditions, as determined by the Surveys personnel in cooperation with the Structures Representative. Generally, for footings, bents, and abutments, a set of reference stakes is established on each side of the structure (see Figure 12-13).

Stakes Set for Superstructures: When feasible, elevation points are provided on footings at the bottom of columns. References for the deck top are provided at sufficient locations on the soffit forms to enable the use of stringlines (or similar methods) to grade the deck. Line points are provided for barrier railings as determined by the Structures Representative.

Color Code: White.

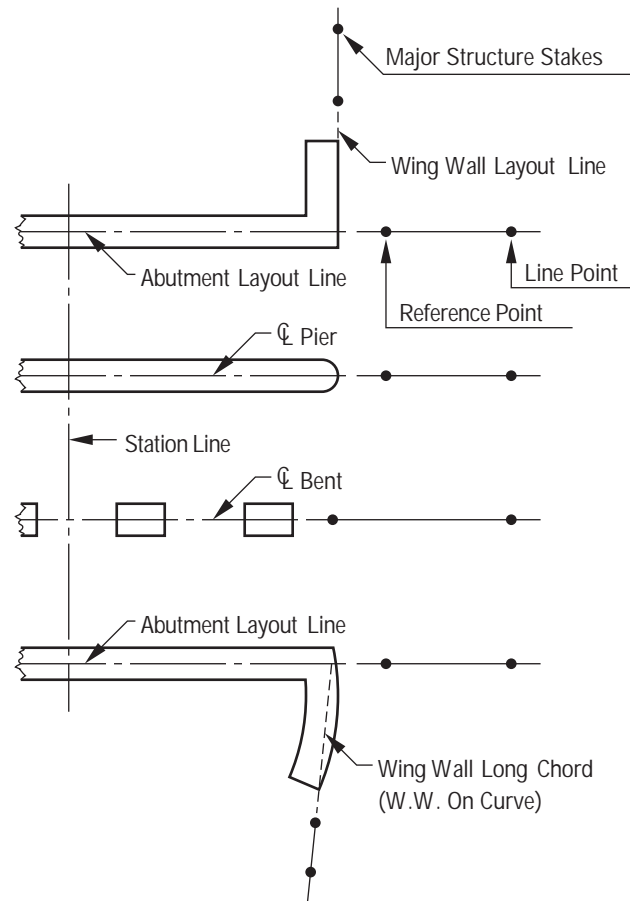


Figure 12-13

Spacing: Space stakes longitudinally every 3 to 10 m along deck and barrier railing lines as determined by the Structures Representative. For barrier railing lines on curved bridges, use the deck edge or reference points at a suitable spacing as determined by the Structures Representative.

Marking: See Figure 12-13A and 12-13B. Reference stakes for major structures provide references for only the controlling lines for the structure and reference elevations.

- a. The identification of the major structure component being staked (abutment, wing-wall, pier, etc.); for Figures 12-13A and 12-13B, Abutment 1 and a wingwall.

- b. The *line* defined by the reference stake and its companion reference stake(s); for each example shown, this is the lay-out-line of the component. Generally, for major structures, a set of stakes will consist of two reference stakes, each providing line, distance, and elevation. Where appropriate, a third “line only” stake also will be set.
- d. The reference point elevation; for Figures 12-13A and 12-13B, 715.485 and 715.124.
- f. The distance from the reference point to the *line being referenced* and the identification of the *line* which is being referenced. The distance is measured along the line identified by stake markings “b” (for Figures 12-13A and 12-13B, the lay-out-line). Cuts or fills are not provided for major structures.

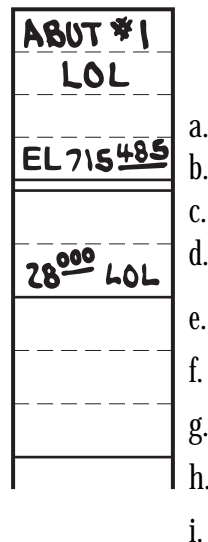


Figure 12-13A

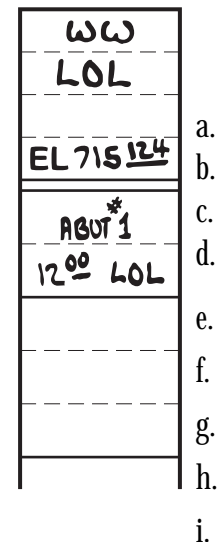


Figure 12-13B

For Figures 12-13A and 12-13B, the distance along the lay-out-line from the reference point to the “A2” stationing line is 28.000 m, and the distance, along the lay-out-line from the reference point to the Abutment 1 lay-out-line is 12.000 m.

Setting Tolerance: Stakes should be set within 10 mm horizontally and 7 mm vertically. (Vertical tolerance is only applicable if a specific elevation is being set.)

Checking: Check staking visually and by reviewing the CTDC Radial Stakeout Reports and/or survey notes. As a further check, distances between stakes set on the ground should be measured and compared against plan distances.

12.5-13 Miscellaneous Stakes

With the exception of contour grading, miscellaneous staking is generally the responsibility of the Resident Engineers' staff. Resident Engineer's requests for the Surveys Branch to perform miscellaneous staking should be approved by the District Surveys Engineer.

Contour Grading

State-furnished construction staking for contour grading varies with the design and terrain. Surveys personnel, in cooperation with the Resident Engineer, will determine the State-furnished stakes provided. Generally, staking at a longitudinal spacing of 20 m will be provided. A "grid" pattern of stakes might be used for areas of relatively shallow fills or cuts. Stakes should be marked in the same manner as rough grade stakes. See Section 12.5-5.

Utilities

Utility work generally is controlled by adjacent construction staking or adjacent facilities, and no State-furnished stakes are set. If separate staking is necessary, as determined by the Resident Engineer in cooperation with the Surveys Branch, State-furnished stakes will be provided in the same manner shown for similar roadway work.

State-furnished stakes are set for sewer lines at a longitudinal spacing of 20 m; a 10 m spacing will be used when the grade is less than 0.3 percent or when the radius of curvature is less than 300 m.

Channels, Dikes, and Ditches

Major channels and dikes are controlled by State-furnished slope stake references. For ditches, State-furnished reference stakes are provided for line and grade breaks, when necessary, as determined by the Resident Engineer.

Signs

When necessary, as determined by the Resident Engineer, State-furnished stakes are provided to locate signs. (See Section 12.5-9, "Minor Structure Stakes".)

Subsurface Drains

State-furnished stakes are set only as determined necessary by the Resident Engineer. Set stakes for subsurface drains in the same manner as for drainage pipes (see Section 12.5-7, "Drainage Stakes"). Stabilization trenches and permeable blankets are controlled by State-furnished slope stakes or contour grading stakes (see Section 12.5-2).

Overside Drains

For straight discharge overside drains, State-furnished stakes (references) are provided only for longitudinal location. Alignment and grade breaks will only be staked at the direction of the Resident Engineer.

Markers

Markers are located by State-furnished stakes (or references), as determined necessary by the Resident Engineer.

Railings and Barriers

Where railings and barriers are controlled by adjacent construction staking or adjacent facilities, no State-furnished stakes are provided, except stakes that establish the beginning and end of each railing or barrier.

Where State-furnished construction staking is necessary, as determined by the Resident Engineer, stakes (references) are provided for alignment and grade at a spacing of 20 m along the facility. 10 m spacing will be used (a) when the radius of curvature is less than 300 m; (b) in areas of superelevation transition; and (c) within 40 m of "conforms" or bridges. A lesser spacing will be used for flares, when necessary, as determined by Surveys personnel.

AC Dikes

State-furnished stakes are provided only at the beginning and end of asphalt concrete dikes.

Box Culverts

State-furnished reference stakes are set for the lay-out-lines of box culverts in the same manner shown in Section 12.5-11, "Wall Stakes." Headwalls and wingwalls are referenced as shown in Section 12.5-12, "Major Structure Stakes."

Pavement Markers

State-furnished references are provided in accordance with the contractual requirements. If the contract does not specify any requirements, one row of references will be provided per traveled way. References will be set every 60 m on tangents, every 40 m on curves with a radius of over 600 m, and every 20 m on curves with a radius of under 600 m.

Normally, no State-furnished references will be provided when pavement markers are placed on portland cement concrete pavement.